

Can we reduce the number of punctures when attempting a percutaneous nephrolithotomy in patients with non-dilated pyelocaliceal systems?

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Abstract. Purpose. Evaluation of a new method for transpapillary puncture of the posteroinferior calix using preoperative CT measurements.

Methods. We studied 35 consecutive patients with renal stones and without dilatation of the renal pelvic caliceal system. In these patients, we determined the exact point of the skin for performing percutaneous nephrolithotomy by measuring the distance between the spine and the lateral projection of the long axis of the posteroinferior calix onto the skin on axial sections with contrast CT. Intraoperatively, we determined the point of puncture under fluoroscopy by crossing the line of the long axis of the calix with the line parallel to the spine at the distance calculated on CT, which can vary significantly.

Results. The first puncture was successful in 26 cases (74.3%), the second puncture in 8 cases (22.8%), and the third puncture in 1 case (2.9%), but at the same skin site as the first or second unsuccessful puncture. The mean number of punctures required to access the calix was 1.29.

Conclusions. This new technique for puncturing the papilla of the posteroinferior calix in its long axis using fluoroscopy and preoperative measurements on contrast scans CT may reduce the number of unsuccessful punctures in undilated pyelocaliceal systems.

Keywords: transpapillary puncture; CT measurements; percutaneous nephrolithotomy; non-dilated renal collecting system

Introduction

Percutaneous access of pyelocaliceal system in the time of percutaneous nephrolithotomy (PCNL) is performed under fluoroscopic guidance [1,2], ultrasound-guided [3], or a combination of these two methods [4]. The rate of successful renal puncture is lower in undilated pyelocaliceal systems compared to dilated pyelocaliceal systems due to difficulties in assessing renal anatomy and thin calix [5]. Puncturing the posteroinferior calix in this particular situation can be a very difficult task because we have to rely only on fluoroscopy, as ultrasonographic visualization of the targeted

calix is impossible. In many cases, even with the help of fluoroscopy (triangulation or bull's eye technique), accurate delineation of the posteroinferior calix cannot be done, and

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many punctures are required in different parts of the skin to reach the calix, which increases the risk of bleeding [6]. Many attempts have been made to improve the success rate of renal punctures [7-12].

To reduce the number of punctures, we performed a preoperative study of the pyelocaliceal system on the contrast study CT to find the exact point of the skin where the needle will enter the papilla. The aim of our study was to evaluate our technique in terms of the number of punctures until reaching the papilla of the desired calyx in its longitudinal axis and the results of this procedure.

Material and Method

Patients

Between 1.01.2017 and 1.03.2020, we included in the study all patients admitted to our clinic with pelvic stones between 2 and 4 cm and with non-dilated pyelocaliceal system, detected first on ultrasound images and then on contrast images CT and who underwent PCNL. We excluded from the study all patients with dilatation of the pyelocaliceal system (N=360), with stones in the posteroinferior calix (N=5), or without preoperative contrast CT (N=13).

Informed consent was obtained from all subjects participating in the study. The study was approved by the Research Ethics Committee of the Clinical Hospital "Dr CI Parhon" (approval number 401/2016). All procedures performed in this study were in accordance with the 1964 Declaration of Helsinki and its subsequent amendments or comparable ethical standards.

The procedure

Before the procedure, we selected the desired posteroinferior calix after CT assessment, through which we had access to the pelvic stone in its longitudinal axis. On axial sections with contrast CT, we measured the distance between the median line and the projection of the long axis of the desired calix

onto the skin (see Figure 1). Intraoperatively, we used this to draw a line parallel to the spine line at the distance measured on CT. With the fluoroscope in the normal position, we visualize the renal pelvic system and the desired calix by injecting retrograde contrast through a ureteral catheter. We determine the point of skin where the puncture should be made by intersecting the line that extends the long axis of the posteroinferior calix with the line parallel to the median line. After establishing the point of the skin and the direction of the needle (18Gy) in this axial plane, we punctured the skin and tilted the fluoroscope 20-30° toward the patient's head to establish the angle of the needle in the sagittal plane. We advanced the needle under fluoroscopic control until we reached the papilla, and then advanced 2-3 mm further into the calix. We did not attempt to advance to the renal pelvis because of the risk of injuring the calix wall. We returned the fluoroscope to a normal position and checked the correctness of the alignments in this plane, so we checked the correct puncture in the long axis of the calix in two planes with the fluoroscope.

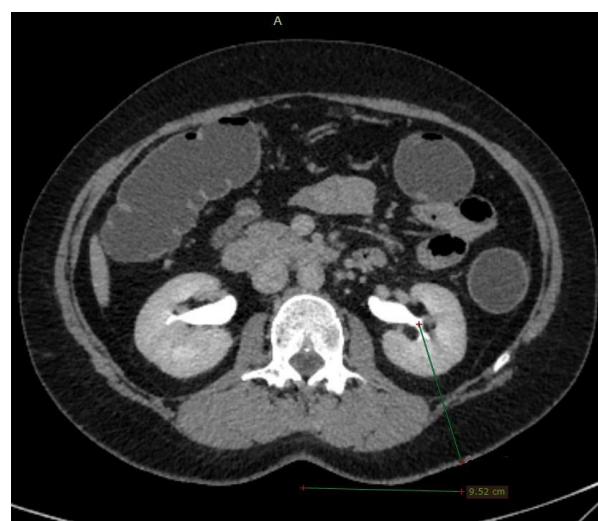


Figure 1. Measurement of lateral projection of the long axis of the postero-inferior calix, calculated on axial sections of CT scan.

At the time of nephroscopy, we considered a transpapillary puncture when we saw the entire circumferential wall of the calix, even when the nephroscope was retracted at the inner edge of the parenchyma. We considered a puncture when the needle transected the parenchyma. There were instances when the needle was advanced, did not reach the parenchyma, and we pulled the needle out due to misalignment. We did not consider this an unsuccessful puncture. The fact that we did not reach the papilla was due to the lack of coordination of advancing the needle with the patient's breathing movements. We did the advancement through the parenchyma at the end of the expiratory phase. In all patients, the kidney was in normal position.

Outcomes

Postoperatively, we appreciated in days hematuria on nephrostomy. If the urine

was clear on the morning of the first postoperative day, we assumed that there was no postoperative bleeding. We discharged the patient only after clearing the urine and removing the nephrostomy tube. We assessed stone clearance by performing radiography and renal echography at discharge.

Statistical analysis

Data are expressed as mean $\pm$ standard deviation (SD), median with interquartile range (IQR), or percent frequency, as appropriate. Normality of distribution was tested using the Shapiro-Wilk test.

Results

During the period mentioned above, we applied this new technique to 35 patients. There were 19 (54.3%) men included in the study and the mean age and BMI were 53.6 years and 27.3 kg/m², respectively (see Table 1).

Table 1. Patients characteristics.

	Total (N=35)
<i>Age, years</i>	53.6 $\pm$ 15.5
<i>BMI, Kg/m²</i>	27.3 $\pm$ 4.4
<i>Male, n (%)</i>	19 (54.3)
<i>Right location, n (%)</i>	15 (42.9)
<i>Hematuria, n (%)</i>	26 (74.3)
<i>Days of hematuria*</i>	1 (1-2)

Data are expressed as mean $\pm$ SD, median with IQR, or percent frequency, as appropriate.

* - only in patients with hematuria.

In 26 patients (74.3%), we succeeded to access the posteroinferior calix by the first puncture, in 8 cases (22.8%) by the second puncture, and in 1 case (2.9%) by the third puncture, but the same puncture site was used as for the first puncture. The majority of punctures were performed on the left kidney (57.1%). All the access points we calculated were medial to the posterior axillary line, between the 12 rib and the iliac crest. There were even points on the skin medial to the lateral border of the paravertebral muscles (see Figure 2).

Thus, we found that the projection of the long axis of the posteroinferior calix onto the skin varied widely and could be anywhere in this range (see Figure 3). We achieved stone-free status in all patients, and although 26 patients (74.3%) had transient hematuria after the procedure, none required blood transfusion. The median (with IQR) and mean postoperative macroscopic hematuria for nephrostomy was 1 day (IQR 1-2 days) and 1.46 days, respectively. No hematomas were noted on echography at discharge.



Figure 2. Projection of the long axis of the calix, medial to the lateral margin of paravertebral muscles.

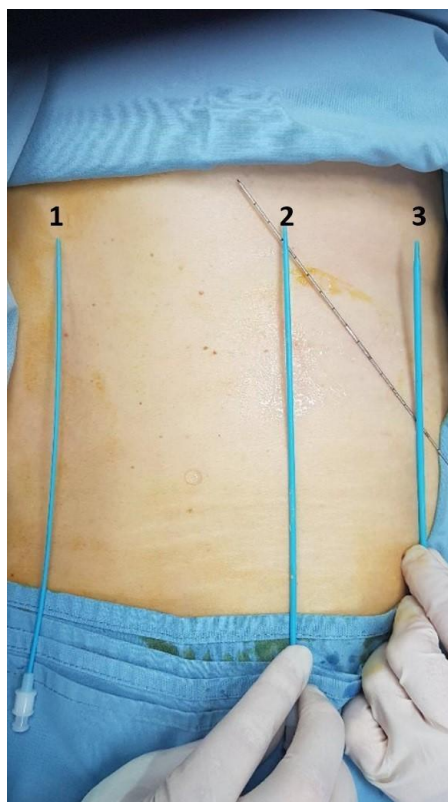


Figure 3. The ideal point of the skin for puncture the postero-inferior calix in his long axis, could be anywhere along the line of the needle placed on the skin under fluoroscopic control, medial to the posterior axillary line. Dilator 1 represents the projection of the spinal line, dilator 2 represents the projection of the lateral paravertebral margin and dilator 3 represents the projection of the posterior axillary line.

Discussions

With this technique we have found the optimal point for the puncture. If we were to begin the puncture from a predetermined point, such as below the 12th rib, from the paravertebral muscle, or from the posterior axillary line, we would not be able to align the needle insertion with the long axis of the calix. Because the axis of the calix is not always in this plane, the needle would form an angle with the calix in the axial plane (see Figure 4), and even if we succeeded in penetrating the calix, the nephroscope would form an angle with the calix in its longitudinal axis, and future movements of the nephroscope would increase this angle, setting the stage for tearing of the parenchyma and concomitant hemorrhage. Our technique has allowed us to limit the number of unsuccessful punctures, with proper alignment that reduces the subsequent risk of parenchymal damage and secondary bleeding.

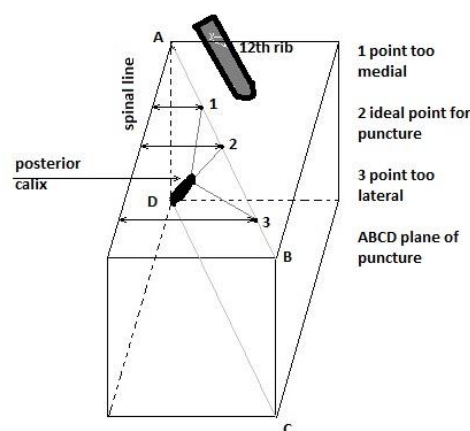


Figure 4. Too medial or too lateral point to puncture, could lead to an improper alignment of the needle with the postero-inferior calix.

There are few studies reporting the number of punctures in non-dilated pyelocaliceal systems [10-12]. The maximum number of attempts to puncture the

calyx was 6 [12]. These studies reported a greater number of punctures than our study.

Nowadays, the generalization of the preoperative uro-scan CT allows a wide use of this technique and can be used by those surgeons who perform the puncture only under fluoroscopic control, but also by those who use both echographic and fluoroscopic control. Despite recent opinions that transpapillary puncture is not necessary to reduce the risk of bleeding at the time of PCNL [13], this approach is considered the gold standard [14-19]. The techniques described to achieve this goal, either fluoroscopic, echographic or a combination of both [4], do not achieve this in satisfactory percentages of over 95% in cases with undilated renal collecting systems [5]. Many authors have used CT to try to improve the rate of successful punctures. They used CT to identify the tissue between the skin and the kidney [20, 21], to identify the spatial relationship of the stone to the kidney [22], to plan which calyx to puncture in patients with renal malformations [23, 24] and obese patients [25], or to build a model based on CT to reconstruct the stone [8]. Only Brehmer et al [26] published a study using a preoperative CT measurement in the sagittal and axial planes to determine the exact point of the skin from which to puncture the desired calyx in complex renal stones, but without quantifying the number of punctures required to access the calyx. In our study, we used only axial CT planes to measure how far laterally from the spinal line to the puncture the exact point was calculated using intraoperative fluoroscopy. The higher success rate of our study was also due to the fact that the targeted calyx did not contain a stone. Although many authors referred to the posterior axillary line or slightly further in as the ideal puncture site [19, 27], we noted considerable variability in this line, which can be anywhere medial to the posterior axillary line. Further studies

with a larger cohort of patients are needed to classify this variability.

Our study has several limitations. First, all procedures were performed by a single surgeon, so future multicenter studies are needed to validate this technique. Second, the number of cases is relatively small. Because of these potential biases, we cannot predict that all sites on the skin will be in the above range to allow perfect alignment of the needle with the axis of the calyx. Another limitation is that the pyelocaliceal system has a large variability, with secondary calyces ranging from very short to very long, which will certainly affect the success of the alignment.

Conclusions

The technique of percutaneous punctures at the time of PCNL, using preoperative CT measurements and intraoperative two-level fluoroscopic control, may help reduce the number of punctures required to access the posteroinferior calyx in its long axis in non-dilating renal collecting systems at the time of PCNL, thereby reducing the risk of intraoperative bleeding, postoperative hematoma, and the need for blood transfusion.

Conflict of Interest

Authors have no conflict of interest to disclose. The study was approved by the Research Ethics Committee of the Clinical Hospital "Dr CI Parhon" (approval number 401/2016).

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